CHAPTER 1

INTRODUCTION

1-1. Scope. This document is limited to the presentation of state-of-the-art prediction methods for ground vibration, airblast, and mass rock movement phenomena; criteria for accidental damage that can be caused by the phenomena described herein; job-specific measurement and instrumentation for airblast and ground vibration; and techniques for reducing the collateral effects of construction blasting. Blasting safety is addressed in EM 385-1-1.

1-2. Background. A necessary part of the planning of all construction blasting operations is the estimation of potential damage to nearby surface and underground structures and to the local rock that is to remain in place and become a part of the completed project as a slope, a wall, or a foundation for a structure. Damage to nearby structures and their occupants can result from ground vibration and airblast (or noise). Damage to subsurface structures such as tunnels can result from ground vibration and subsequent surface rock or liner spall. Damage to rock slopes, walls, or foundations can occur as crack propagation into the solid rock or explosive gas pressure migration along these cracks or pre-existing joints or bedding planes.

Damage caused by blasting is not a precise process. While the variables of the blast design can be controlled, there is some variation in the strength of an explosive and the actual delay time between the individual explosions that comprise a round. There is substantial random variation in the vibration propagation characteristics of the rock, the airblast propagation characteristics of the atmosphere (weather changes), and the strength and ductility of the nearby man-made structures. This means that until a substantial body of experience has been collected at a given site, there is a nontrivial probability that the next blast will produce more damage than the last previous one of like size. This must be kept in mind when assessing blasting safety.

1-3. Definitions. The following definitions and terms are used in this document:

a. Radius (R), also referred to as Range, the horizontal distance from the center of an explosive charge to a point where ground motion or airblast is to be estimated.

b. Charge per Delay (W), the weight of explosive detonated at one time (for practical purposes, this is the weight of explosive detonated by a single delay and, depending on the length of detonating cord and the specific arrangement of the charge, may actually occur over a few milliseconds.

c. Total Charge (W_T), the weight of explosives detonated in a single operation (round); that is the sum of the charge weights for the sequential delays that comprise the round and which are detonated within a few milliseconds of one another.

d. Explosive - A chemical compound or mixture of compounds that when heated or shocked by the explosion of a cap, squib or booster explosive undergoes a rapid exothermic reaction releasing large quantities of gas at high temperature and pressure.

e. Delay - A device placed in the electrical circuit between the blasting cap which is inserted in the charge and the blasting machine which causes a pre-set retardation in time of the detonation. Delays are used to control fragmentation, improve the efficiency of the shot and reduce vibration and airblast levels. This term also indicates the time interval between detonations, for example, a delay of 100 milliseconds (msec).

f. Stemming - Loose material placed in the borehole above or below the explosive for the purpose of temporarily confining the gaseous explosive products, or separating explosives.

g. Burden - The rock between the explosive loaded borehole or boreholes and a free face. This is the rock which is to be broken for removal.

h. Spacing - The lateral distance between loaded boreholes.

i. Powder Factor - The weight of explosive required per unit volume of rock to be excavated, usually expressed in units of lb/cu yd.

1-4. Geologic Investigation. An understanding of the lithology and structure of the rock to be excavated by blasting, including jointing, bedding, and faults, is key to the understanding of rock mass displacement. As damage due to rock mass displacement is most difficult to repair and impacts on the performance of the project foundation, it is imperative that damage be prevented by careful blast design in the vicinity of final excavation lines.

1-5. Method of Application. Appendix B of Item 1 presents several example excavation specifications which include provision for rock blasting for CE projects. The only CE guide specifications that treat rock blasting are CEGS-02230 and MOGS-02230. They require only a general blasting plan and make the contractor responsible for any damage that occurs. Some of the sample project specifications in Reference 3.d. (Item 1) require the contractor to submit to the Resident Engineer a general blasting plan before any rounds are drilled and loaded. Some require a specific plan before each round. Some of these specifications contain restrictions or prohibitions on certain possible contractor actions. These restrictions are intended to prevent gas pressure or fracture damage to the rock foundation and slopes, cracking of concrete placed on the project, or damage to preexisting Government-owned structures. Damage to existing structures in most cases has been explicitly made the responsibility of the contractor. How the technical information contained herein is used depends on the specification controlling the blasting operation. Since EM 385-1-1, the Safety Manual, is usually made a part of CE project specifications, Section 25C of that reference describing vibration damage and control criterion is enforced by the Resident Engineer.